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Factors Affecting Waterfowl Brood Use of Stock Ponds in South Dakota

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FACTORS AFFECTING WATERFOWL BROOD USE OF STOCK PONDS IN SOUTH DAKOTA

BY

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STOCK PONDS IN SOUTH DAKOTA

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusion of the major department.

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Abstract

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A July waterfowl brood survey was conducted from 1973 to 1976 on stock ponds located within four physiographic strata in South Dakota. Information was collected on weather, stock pond characteristics, land use and the condition of other wetlands located within the quarter section (64.8 ha) study plots.

Multiple regression and multiple discriminant analyses were used to determine the importance of these variables in influencing brood use of stock ponds. Vegetation type, distribution of emergent vegetation and pond size were important in determining if broods of any particular species utilized a pond or not. Shoreline distance was particularly important in explaining variation in brood densities. Highest brood densities occurred on stock ponds of 0.40 to 1.00 ha surface-water area. Blue-winged teal (*Anas discors*) broods were positively associated with alfalfa and negatively associated with total stream area on the study plot. Mallard (*Anas platyrhynchos*) broods were negatively associated with pasture and hayland. Pintail (*Anas acuta*) and gadwall (*Anas strepera*) broods exhibited a positive association with stock ponds that had a dispersed pattern of vegetation and were located in areas of high surrounding wetland densities. Older broods of all four species combined (subclass IIc and class III) were positively associated with stock ponds having a stable water level and emergent vegetation.

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INTRODUCTION

Stock ponds are formed by earthen dams constructed across natural waterways and are used primarily as a water source for livestock. The construction and distribution of stock ponds in areas where natural wetlands are sparse or lacking increases waterfowl production (Bue et al. 1964).

In 1937, the Range Program was started by the U. S. Department of Agriculture. Its purpose was to provide stock-watering ponds throughout the rangelands of the U. S. (Bue et al. 1952). Today, there are over 88,000 estimated stock ponds located throughout South Dakota (Ruwaldt 1975). Construction of stock ponds has coincided with the drainage of natural wetlands in eastern South Dakota. This drainage has increased the importance of stock ponds to waterfowl production in South Dakota.

Limited work has been done concerning the importance of habitat variables associated with stock ponds and waterfowl production. Smith (1953) and Berg (1956) reported that the size of the stock pond was more important than the amount of emergent vegetation in determining the number of waterfowl broods per pond. Bue et al. (1952) and Mundinger (1976) reported that intensive grazing immediately adjacent to a stock pond lowered the number of broods present on the pond. Lokemoen (1973) statistically analyzed a larger number of variables including pond size, vegetation and grazing. He reported stock pond size to be the major environmental factor influencing number of broods per pond.

The objective of this study was to determine the relative importance of land use and various stock pond characteristics to the use of stock ponds by waterfowl broods in general and by species in particular. Such information is imparative in defining management objectives for obtaining maximal waterfowl production on South Dakota stock ponds. Data for this study was obtained from a state-wide waterfowl survey conducted from 1973 to 1976.

STUDY AREA

South Dakota encompasses an area of 199,552 km^2. Agriculture is the main industry. The chestnut soils of the western half of the state are used primarily for rangeland and wheat. The chernozem soils of the eastern half are used for pasture, corn and small grain crops (Westin et al. 1967).

Climate

South Dakota has a continental climate with hot summers and cold winters. Mean annual air temperature ranges from 6.7 C in the north to 8.9 C in the south. The mean number of frost-free days varies from 130 days in the north to 160 days in the south (Spuhler et al. 1971). The mean precipitation varies from 35 cm in the northwest to 60 cm in the southeast. Average annual lake evaporation ranges from 80 cm in the northeast to 110 cm in the southwest (Kohler et al. 1959). Approximately 80 percent of the evaporation occurs during the growing season.

Physiography

Physical division by natural land forms separates the state into two main regions, the Missouri Plateau and the Central Lowland (Figure 1). The Missouri Plateau is divided into five main strata; Missouri Coteau, Northern Plateau, Southern Plateau, Pierre Hills and Black Hills. Study ponds were located in the four prairie strata (excludes Black Hills) of the Missouri Plateau.

The Missouri Coteau is separated from the rest of the Missouri

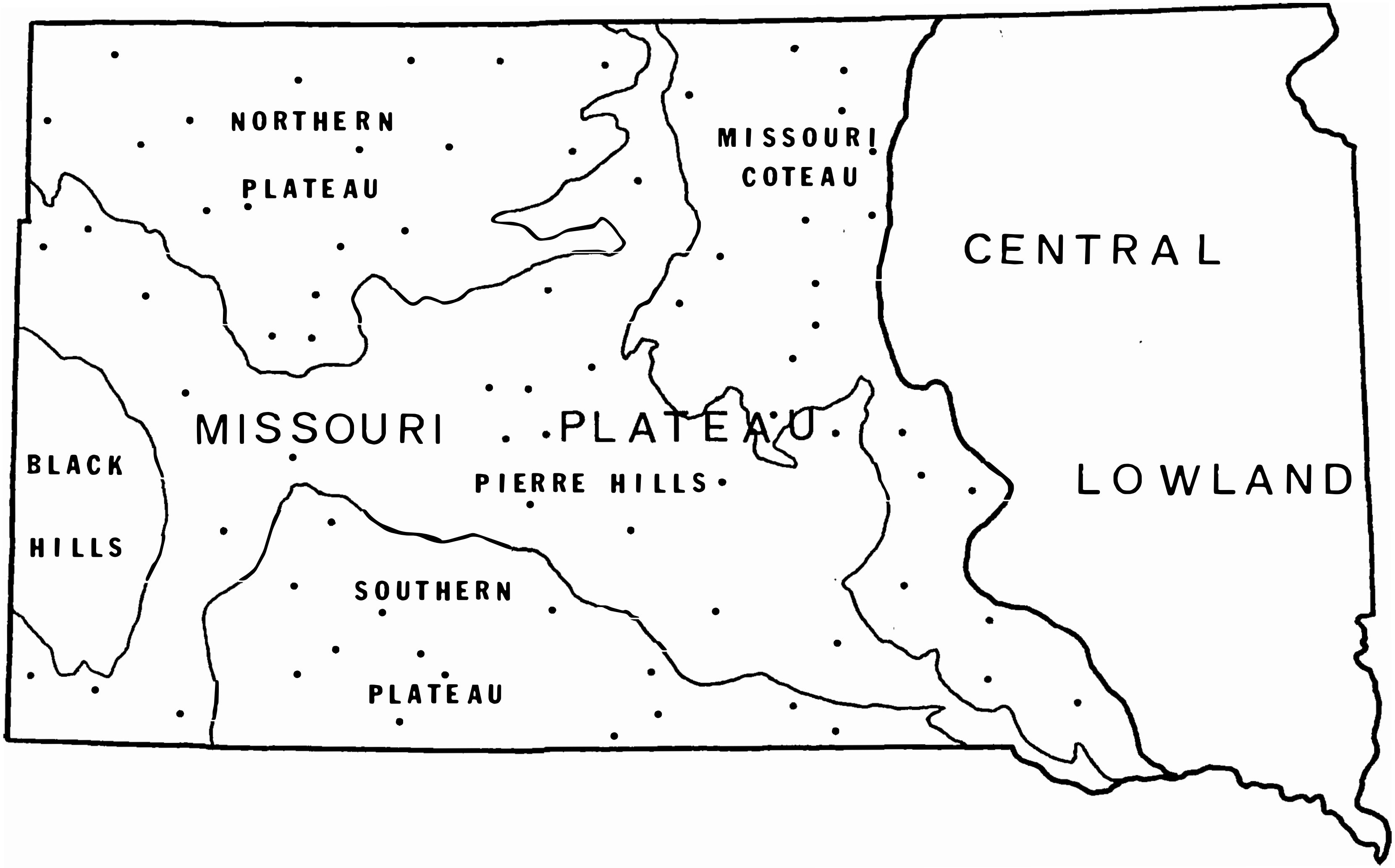

Figure 1. Physiographic strata within South Dakota and the location of the clusters of four quarter-section (64.8 ha) study plots within the Missouri Plateau.

Plateau region by the Missouri River. This stratum is covered by glacial deposits and has a rolling topography. The area has a higher density of natural wetlands than any of the other three strata. The northern portion tends to have deeper, more permanent wetlands. The southern portion contains almost all the stock ponds located in this stratum. The Northern Plateau contains a series of plateaus and isolated buttes (mean elevation is 900 m). This stratum has numerous intermittent streams. The Southern Plateau is a series of benches and buttes with a range in elevation from 610 to 915 m. The Pierre Hills has a smooth undulating topography that consists of hills and ridges. Elevation ranges from 540 to 840 m, which is lower than the adjoining plateau regions (Westin et al. 1967).

Vegetation and Land Use

South Dakota with the exception of the Black Hills is located in a grassland biome. The Missouri Plateau is located in the mixed-grass prairie association (Johnson and Nichols 1970). The principal native vegetation of the mixed-grass prairie is western wheatgrass (*Agropyron smithii*), blue grama (*Bouteloua gracilis*), needleandthread (*Stipa comata*) and green needlegrass (*Stipa viridula*). Intensive grazing by livestock has caused short-grass associated species to become more dominant in some areas (Johnson and Nichols 1970). Between 1961 and 1966, the approximate percentages of rangeland or pasture in the area varied from 61 percent in the Missouri Coteau to over 90 percent in the more arid portion of western South Dakota (Westin et al. 1967).

However, each year an increasing amount of this native grassland is plowed and sown into small grain.

METHODS

Sampling

Seventy-four cluster sites were randomly chosen in the four strata of the Missouri Plateau. Sample areas, referred to as clusters, contained a 6.43 km radius in which one 64.8 ha (160 acres) quarter section was randomly picked from each quadrant of the circle. The percentages of each stratum sampled was: Missouri Coteau, 0.18; Northern Plateau, 0.15; Southern Plateau, 0.17; and Pierre Hills, 0.11. Lower sampling effort was conducted on the Pierre Hills because of the large size and homogeneity of the area. The legal quarter section was chosen as the study plot size because it usually is defined by boundaries, such as fence rows, roads, or shelterbelts and because two observers could adequately cover the plot. Birds flushed within the study plot usually flew off the plot, therefore reducing the chance of counting a bird twice.

Aerial photographs of each study plot were obtained from the Agricultural Stabilization and Conservation Service and enlarged to a scale of 1:3960. The photographs were used to locate plots and to map basin size, surface water, emergent vegetation and upland land use.

Census

Brood censusing began the second week of July and lasted approximately 10 days depending on the wetness of the year. All plots were surveyed by two 2-man teams. The brood survey started in the southern portion of the state and progressed northward to help compensate for the lag in the reproductive season between the northern and southern part of the state. Because of the extent of the census and the limited time and man-power available, brood censusing was conducted throughout the daylight hours. Flushing of broods from emergent vegetation was done using a walk-wade technique described by Hammond (1969). Size, age (Gollop and Marshall 1954), and species of each brood observed were recorded. Adult females which exhibited a distracting display when no ducklings were flushed were assumed to have a brood hidden and noted as such. Any brood for which the age or species was not positively determined was recorded as an inaccurate observation.

Values for wetland habitat variables and climatic conditions were collected during the census. Upland cover-type variables were recorded only during a breeding pair census in May because it represented land use during nest initiation. Basin size, shoreline distance and hectares of upland cover types were measured from mapped aerial photographs using a planimeter and map measure. Pond depth or fullness was rated on a gradient from 1 to 4: fullness 1 (water level above normal), fullness 2 (water level normal to 25 percent low), fullness 3 (more than 25 percent but less than 75 percent reduction in water level) and fullness 4 (at least 75 percent reduction in water level). Cover-type classification was according to Steward and Kantrud (1971). The pattern of emergent vegetation was classified as one of four types: cover-type 1 (less than 5 percent open water), cover-type 2 (5 to 95 percent open water with scattered dense patches of vegetation), cover-type 3 (at least 5 percent open water with a peripheral stand of vegetation 1.8 m or more in width), and cover-type 4 (more than 95 percent open water with a narrow band of emergents less than 1.8 m in width). Grazing intensity was determined from the condition of the emergent vegetation and adjacent upland within 100 m of the pond and was subjectively rated from none to heavy (0-3). Ocular estimates of grazing intensity were used because large sample size and limited time available prevented the use of more precise measuring techniques. Shoreline development was computed from the mathematical relationship between shoreline distance and surface-water area as described by Lind (1974). Emergent vegetation species that were dominant were recorded for each stock pond.

Analysis

Statistical analysis was conducted on stock ponds with over 90 percent of the basin area located on a study plot. Stepwise forward multiple regression (Snedecor and Cochran 1967) and stepwise forward discriminant analysis (Cooley and Lohnes 1971) were used in the data analysis. In stepwise forward regression, the first variable entered into the equation is the single variable that explains the greatest amount of variance in the dependent variable. Each variable entered thereafter, is the one that explains the greatest amount of variance remaining within the dependent variable after the effects of each variable already entered and their interactions are removed from the dependent variable (Snedecor and Cochran 1967). The standardized partial regression coefficient indicates the relative importance of each independent variable within the equation in terms of ability to predict or estimate the dependent variable (Steel and Torrie 1960).

Regression analysis, with all species of broods combined, was run two separate ways: (1) using all wet stock ponds and (2) using just ponds with brood(s) present. By using all stock ponds, analysis would indicate which variables are important in determining the suitability of the pond for broods. Analysis, using just brood ponds, indicates which variables are important in determining the productivity of a pond that is suitable for broods. Separate regression analyses for mallard (Anas platyrhynchos) and blue-winged teal (Anas discors) were used to determine the difference in species preference for various habitat variables. Only ponds with the species of interest present were used in this analysis. Analyses on pintail (Anas acuta) and gadwall (Anas strepera) were not possible because few ponds contained more than one brood of either pintails or gadwalls. The dependent variable in each analysis was expressed as a density in order to standardize the pond size and its relationship to total brood numbers.

In discriminant analysis the dependent variable is not continuous. Broods are reported as being either present or absent; the total number is not important. Because of this, discriminant analysis determines which habitat variables are best able to separate between the groups. The discriminant function value indicates the discriminating ability and the relationship of the independent variable with each group. Values of the discriminant function are used to plot the location of group centroids. Like signs for both the function value and the group centroid indicate a direct association between the two. The values of the within-group means also shows an association between the variable and the group. However, on occasion, the relationship indicated by the signs and the relationship shown by group means may be opposite. This may be due to both the high correlation between variables and the low discriminating ability of the variable. In stepwise forward discriminant analysis, variables are entered according to their ability to discriminate between groups. The first variable entered is the most important discriminant variable. Each variable entered thereafter is the one best able to discriminate between groups after the effect of prior variables is removed (Klecka 1975). The list of variables was terminated at the point where additional variables had little discriminating effect in the analysis. Prior probabilities were used in the classification of cases into groups. Prior probability was equal to the proportion of cases falling into each group before classification was instituted (Klecka 1975).

Discriminant analysis was conducted to determine which variables were most important in determining presence or absence of a particular species, in discrimination between species in pond selection, and in comparing age-specific differences in brood habitat selection. In discriminant analysis by age, broods were sorted into three age-groups: (1) class I, (2) subclass IIa, IIb and (3) subclass IIc, class III. Age-groups were divided in this manner so that there would be a sufficient sample size in each group for statistical analysis. Significant differences ($P<.01$ and $P<.05$) in means of discriminant groups was determined by the use of the univariate F-ratio.

Since the year was assumed to be random, data from the four years was combined in all analyses. Thirty-seven independent variables (Table 1) were used in all analyses. Strata, cover-type and fullness were treated as dummy variables (Blalock 1960) since values within each variable were neither continuous nor linear.

Table 1. Independent variables used in multiple regression and discriminant analysis of duck broods on South Dakota stock ponds.

Non-habitat	
Temperature	Air temperature (C)
Wind	Wind velocity (meters per hour)
Cloud cover	Percent overcast
Time	Time of observation, reported to the nearest hour
Upland land use	
Strata[a]	Four physiographical regions
Small grain	Hectares of small grain located on the plot
Row crops	Hectares of row crops located on the plot
Alfalfa	Hectares of alfalfa located on the plot
Hayland	Hectares of hayland located on the plot
Pasture	Hectares of pasture located on the plot
Non-use grassland	Hectares of undisturbed grassland on the plot
Farmstead	Hectares of farmstead on the plot
Fallow	Hectares of idle (not planted) cropland on the plot
Water-basin	
Basin size	Hectares of stock pond basin
Surface-water area	Hectares of stock pond surface water
Percent surface water	Percent of stock pond basin with water
Fullness[a]	Gradient rating of pond water level (1 to 4)
Shoreline distance	Length of shoreline (m)
Shoreline development	Relationship between the shoreline length and surface-water area
Total basins	Total number of basins on the plot
Total wet basins	Total number of basins on the plot with water
Total stock pond basin	Total basin area of stock ponds on the plot (ha)
Total stream basin	Total basin area of intermittent streams on the plot (ha)
Total stock pond water	Total surface-water area of stock ponds on the plot (ha)
Total stream water	Total surface-water area of intermittent streams on the plot (ha)
Vegetation	
Typha[b]	Occurrence of *Typha* spp. as a dominant emergent
Scirpus[b]	Occurrence of *Scirpus* spp. as a dominant emergent
Sagittaria[b]	Occurrence of *Sagittaria* spp. as a dominant emergent
Alisma[b]	Occurrence of *Alisma* spp. as a dominant emergent
Sparganium[b]	Occurrence of *Sparganium* spp. as a dominant emergent
Eleocharis[b]	Occurrence of *Eleocharis* spp. as a dominant emergent
Vegetation height	Mean height of emergents above surface water (cm)
Open-water area	Hectares of stock pond surface water free of emergent vegetation
Percent open water	Percent of stock pond surface water free of emergent vegetation
Cover-type[a]	Classification of the vegetative pattern on the pond (1 to 4) (Stewart and Kantrud 1971)
Percent grazing	Percent of the pond's shoreline grazed
Grazing intensity	Intensity of grazing on the shoreline and the immediate upland, rated from 0 to 3

[a] Dummy variables
[b] Dichotomous variables

RESULTS

Stock ponds and average brood number on study plots were not proportionately distributed among the four strata (Table 2). The Pierre Hills contained over 50 percent of the study ponds but produced only 38.5 percent of the broods observed. The Missouri Coteau contained the lowest percentage of stock ponds (12.0) but produced 20.7 percent of the total broods. Almost one-half of all stock ponds in the Missouri Coteau had broods present compared to approximately one-fourth in each of the other strata. Average number of broods per pond ranged from 0.59 (Pierre Hills) to 1.33 (Missouri Coteau). Total numbers of broods of each species were: blue-winged teal, 87; mallard, 67; pintail, 22; gadwall, 16; and other species and unidentified broods, 21. Other species included american wigeon (*Anas americana*), green-winged teal (*Anas crecca*) and northern shoveler (*Anas clypeata*).

Average number of broods per hectare of surface water exhibited a non-linear relationship with surface-water area of stock ponds (Table 3). The productivity of stock ponds with 0.01 to 0.10 ha of surface water as expressed by density is deceiving. Three of the four broods within this size group of ponds occurred on stock ponds with less than 50 percent of the basin having water. One particular brood was located on a pond with a basin size of 2.57 ha but only 0.05 ha of surface water. A reduction of water on ponds with less than 0.10 ha of surface water may result in dry ponds before brood development is complete. Broods per hectare of surface water increased to the 0.41 to 1.00 size and then decreased. Brood density for all ponds averaged 0.37 broods per hectare of surface water.

Table 2. Distribution of stock ponds and broods on stock ponds within the four study strata in South Dakota.

	Missouri Coteau	Northern Plateau	Pierre Hills	Southern Plateau	Total
Area (km^2)	27,995	30,093	52,821	20,813	131,722
% of study area	21.3	22.8	40.1	15.8	100.0
No. of stock ponds	33	55	139	49	276
% of total stock ponds	12.0	19.9	50.3	17.8	
% of stock ponds with broods	48.5	25.5	26.6	28.6	
% of total broods	20.7	26.8	38.5	14.1	
Average broods per stock pond	1.33	1.04	0.59	0.61	0.77

Table 3. Brood use related to surface-water area of stock ponds in South Dakota.

Water area (hectares)	Total no. wet ponds	$\bar{X}$ broods /hectare	$\bar{X}$ broods /pond	Total broods
0.01–0.10	64	1.41	0.06	4
0.11–0.20	36	0.60	0.19	3
0.21–0.40	53	1.24	0.38	20
0.41–1.00	73	1.35	0.92	67
1.01–2.00	32	1.01	1.41	45
2.01 +	18	0.63	3.50	63
Total or mean	276	0.92	0.73	202

Variables Associated with Variation in Brood Density

Total brood density

Six variables were significant ($P<.05$) in explaining the suitability of stock ponds for broods (Table 4). Three variables (Missouri Coteau, percent open water, and fallow) were significant ($P<.01$) and accounted for 9.4 percent of the variance in total broods. Cover-type 3, cover-type 1 and *Sagittaria* spp. helped increase ($P<.05$) the coefficient of determination to 14.4 perecent. Variables associated with the distribution of emergent vegetation (percent open water, cover-type 3, and cover-type 1) showed negative standardized partial regression coefficients and simple correlation coefficients. Values of the standardized partial regression coefficient within the equation showed percent open water and the Missouri Coteau as having the most influence in determining if a pond would be used by broods. Pasture had a simple correlation coefficient of - 0.17 (second only to Missouri Coteau) but was not entered into the equation. Pasture probably did not enter the regression equation due to the removal of a large portion of the variance by a previously entered and correlated variable, Missouri Coteau.

Six variables significantly ($P<.05$) explained the variance in brood density on ponds that had brood(s) present (Table 5). Percent surface water, shoreline distance and percent open water explained 41.5 percent of the variance ($P<.01$) in total brood density. All three variables exhibited a negative regression and correlation coefficient. Alfalfa, *Alisma* spp. and fallow ($P<.05$) helped increase the coefficient

Table 4. Stepwise forward multiple regression analysis of brood density and habitat variables associated with stock ponds[a].

Dependent variable	Independent variables[b]	Std. part. regr. coef. (b) $P<.05$	$P<.01$	Coef. of deter. (R^2)	Change in R^2	Simple corr. coef. (r)
Total brood density[c]	Missouri Coteau	+ 0.2204	+ 0.2236	0.0372	0.0372	+ 0.1928
	Percent open water	– 0.2944	– 0.1951	0.0721	0.0349	– 0.1617
	Fallow	+ 0.1738	+ 0.1490	0.0943	0.0222	+ 0.1315
	Cover-type 3	– 0.1970		0.1100	0.0157	– 0.0378
	Cover-type 1	– 0.1711		0.1280	0.0180	– 0.0337
	Sagittaria	+ 0.1398		0.1439	0.0159	+ 0.1271

[a]Regression using all stock ponds including those without broods (sample size = 276)
[b]Variables listed in order of their ability to explain variance in the dependent variable. First variable listed explains the most.
[c]Broods/hectare of surface water for all species of broods combined

Table 5. Stepwise forward multiple regression analysis of brood density and habitat variables associated with stock ponds having a brood present[a].

Dependent variable	Independent variables[b]	Std. part. regr. coef. (b) P<.05	Std. part. regr. coef. (b) P<.01	Coef. of deter. (R^2)	Change in R^2	Simple corr. coef. (r)
Total brood density[c]	Percent surface water	- 0.4116	- 0.4326	0.2172	0.2172	- 0.4661
	Shoreline distance	- 0.4361	- 0.4227	0.3219	0.1047	- 0.4335
	Percent open water	- 0.4025	- 0.3261	0.4153	0.0934	- 0.0934
	Alfalfa	+ 0.1892		0.4634	0.0481	+ 0.2048
	Alisma	- 0.2712		0.5012	0.0378	- 0.1299
	Fallow	+ 0.2419		0.5525	0.0513	+ 0.2484

[a]Sample size = 83
[b]Variables listed in order of their ability to explain variance in the dependent variable. First variable listed explains the most.
[c]Broods/hectare of surface water for all species of broods combined.

of determination to 55.3 percent. Open-water area and total stock pond water were nonsignificant even though they had a simple correlation coefficient greater than 0.35. These two variables were nonsignificant probably because of their high correlation with shoreline distance ($r>0.85$).

Blue-winged teal

Blue-winged teal broods were significantly related ($P<.01$) to shoreline distance, alfalfa, percent open water, percent surface water and the Northern Plateau (Table 6). These five variables explained 52.5 percent of the variance in teal brood density. Both regression and simple correlation coefficients indicated that shoreline distance, percent open water and percent surface water were all negatively associated with teal brood density. Alfalfa and the Northern Plateau had a positive regression coefficient. Total stream basin, temperature, open-water area, total stream water and *Sagittaria* ($P<.05$) helped account for 68.3 percent of the variance in teal brood density. Surface-water area and total stock pond water had relatively high simple correlation values (over 0.35), but were not entered in the equation probably due to their high correlation with shoreline distance (0.90 and 0.89 respectively).

Mallard

Within the regression of mallard brood density (Table 7), six variables were significant ($P<.01$): shoreline distance, percent open water, percent surface water, hayland, open-water area and fallow. Variance in brood density explained by these variables was 64.2 percent. Shoreline distance, percent open water, percent surface water and hayland were negatively associated with brood density. The Northern Plateau,

Table 6. Stepwise forward multiple regression analysis of blue-winged teal brood density and variables associated with stock ponds having a blue-winged teal brood present.

Dependent variable	Independent variables[a]	Std. part. regr. coef. (b) P<.05	Std. part. regr. coef. (b) P<.01	Coef. of deter. (R^2)	Change in R^2	Simple corr. coef. (r)
Blue-winged teal density[b]	Shoreline distance	- 0.8807	- 0.5386	0.2394	0.2394	- 0.4893
	Alfalfa	+ 0.4754	+ 0.4185	0.3677	0.1283	+ 0.4089
	Percent open water	- 0.6570	- 0.3762	0.4336	0.0659	- 0.0666
	Percent surface water	- 0.4683	- 0.3151	0.4762	0.0426	- 0.2495
	Northern Plateau	+ 0.1943	+ 0.2468	0.5252	0.0490	- 0.0535
	Total stream basin	- 0.3509		0.5617	0.0365	- 0.1967
	Temperature	- 0.1650		0.5993	0.0376	- 0.0884
	Open-water area	+ 0.3151		0.6335	0.0342	- 0.4467
	Total stream water	+ 0.3106		0.6523	0.0188	- 0.1835
	Sagittaria	- 0.2189		0.6833	0.0310	- 0.1002

[a]Variables listed in order of their ability to explain variance in the dependent variable after the effect of previous variables entered are removed from the dependent variable

[b]Blue-winged teal broods/hectare of surface water

Table 7. Stepwise forward multiple regression analysis of mallard brood density and variables associated with stock ponds having a mallard brood present.

Dependent variable	Independent variables[a]	Std. part. regr. coef. (b) P<.05	Std. part. regr. coef. (b) P<.01	Coef. of deter. (R^2)	Change in R^2	Simple corr. coef. (r)
Mallard density[b]	Shoreline distance	- 1.5538	- 1.4004	0.2039	0.2039	- 0.4515
	Percent open water	- 0.6723	- 0.5404	0.3104	0.1065	- 0.2215
	Percent surface water	- 0.5805	- 0.2362	0.4241	0.1137	- 0.4287
	Hayland	- 0.3443	- 0.3056	0.4984	0.0743	- 0.0287
	Open-water area	+ 0.9635	+ 0.9037	0.5494	0.0510	- 0.3645
	Fallow	+ 0.3139	+ 0.3414	0.6418	0.0924	+ 0.3199
	Northern Plateau	+ 0.3530		0.6935	0.0517	- 0.1349
	Temperature	- 0.2369		0.7343	0.0408	- 0.0325
	Fullness 4	- 0.2273		0.7627	0.0284	+ 0.2454

[a]Variables listed in order of their ability to explain variance in the dependent variable after the effect of previous variables entered are removed from the dependent variable

[b]Mallard broods/hectare of surface water

temperature and fullness 4 helped increase the coefficient of determination to 76.3 percent. Open-water area, the Northern Plateau and fullness 4 showed opposite signs for the regression coefficient and the correlation coefficient. The difference in signs indicated that an interaction between variables occurred within the equation. This interaction caused the variable to have a different relationship with mallards than when the effect of all other variables was ignored. Shoreline development had a simple correlation of - 0.37 but was not entered in the analysis.

Variables Associated with Presence or Absence of Broods on Ponds

Total broods

Discriminant analysis was run to discriminate ponds into two groups; ponds with brood use and ponds without brood use (Table 8). It was assumed that the presence of one or more broods on a pond indicated that physical characteristics of the pond and the surrounding upland were suitable for brood use.

Four main variables—shoreline distance, *Scirpus* spp., *Sagittaria* and the Missouri Coteau accounted for most of the discrimination between the two groups. Shoreline distance was the single most discriminating variable. The indirect or negative discriminant function sign on shoreline distance along with the negative sign on the brood pond centroid indicated a direct or positive association. *Scirpus*, *Sagittaria* and the Missouri Coteau were all directly associated with brood ponds. The difference in the mean of the variable within each group was significant ($P<.01$) for all except the Missouri Coteau (Table 9). The mean shoreline

Table 8. Major independent variables separating between stock ponds with one or more broods present and stock ponds without a brood present as indicated by stepwise forward discriminant analysis.

Group	No. of cases	% of total obs.	% of obs. correctly classified	Group centroid[a]	Major discr. variable[b]	Standardized discr. function
Brood ponds	83	30.0	48.2	- 0.8453	Shoreline distance	- 0.6888
Non-brood ponds	193	70.0	93.3	+ 0.3635	*Scirpus*	- 0.3308
					Sagittaria	- 0.3184
Total	276		79.7		Missouri Coteau	- 0.3140

[a] Centroid in reduced space of the discriminant scores

[b] Main discriminant independent variables are listed in the order of their ability to discriminate between groups. The ability of each variable is dependent on the ability of the variables listed prior to it.

Table 9. Within-group means (percent[a]) of major variables discriminating between stock ponds with one or more broods and stock ponds without any brood present.

Variable	Brood ponds	Non-brood ponds	Total
Shoreline distance[b] (m)	717	267	402
Scirpus[b] (%)	39.8	8.3	17.8
Sagittaria[b] (%)	18.1	6.2	9.8
Missouri Coteau (%)	19.3	8.8	12.0

[a] *Scirpus, Sagittaria* and Missouri Coteau are dummy variables and are represented as the percent of the ponds within each group that had this variable present.
[b] The difference in means between groups is significant ($P<.01$).

distance of ponds with a brood(s) present was 717 m compared to 267 m for non-brood ponds. *Scirpus* occurred on almost 40 percent of the ponds with one or more broods and only 8.3 percent of the ponds without. Almost 80 percent of the stock ponds were correctly classified into their respective group by these four variables.

Blue-winged teal

Six variables correctly classified 84.4 percent of the 276 ponds in the analysis (Table 10). Blue-winged teal broods were present on 19.6 percent of the ponds; of these, 44.4 percent were correctly classified by the top six discriminating variables. *Scirpus* was the most important single variable positively associated with blue-winged teal. However, within the complete equation, shoreline distance was the most important overall variable (discriminant function value equals - 0.9067). All variables, except open-water area, had a direct relationship with teal. The difference in means was significant ($P<.01$ or $P<.05$) for all variables except cover-type 4 (Table 11). *Scirpus* occurred on 48.2 percent of the teal ponds but on only 10.4 percent of the ponds without teal broods.

Mallard

Shoreline distance, pasture, *Sagittaria* and fullness 1 were responsible for correctly classifying 87.7 percent of the ponds (Table 10). Mallard ponds comprised 15.6 percent of all the ponds with 39.5 percent of these correctly classified. Considering the complete equation, shoreline distance showed twice the discriminating ability (standardized discriminant function equals - 0.7510) as the second most important

Table 10. Major independent variables separating between stock ponds with a species of brood present and stock ponds with the species absent as indicated by stepwise forward discriminant analysis.

Group	No. of cases	% of total obs.	% of obs. correctly classified	Group centroid[a]	Major discr. variable[b]	Standardized discr. function
B. w. teal ponds	54	19.6	44.4	- 1.1111	*Scirpus*	- 0.5291
Non-teal ponds	222	80.4	94.1	+ 0.2703	Missouri Coteau	- 0.4180
Total	276		84.4		Shoreline distance	- 0.9067
					Eleocharis	- 0.3311
					Cover-type 4	- 0.2826
					Open-water area	+ 0.4563
Mallard ponds	43	15.6	39.5	- 1.2120	Shoreline distance	- 0.7510
Non-mallard ponds	233	84.4	96.6	+ 0.2237	Pasture	+ 0.3599
Total	276		87.7		*Sagittaria*	- 0.3201
					Fullness 1	- 0.3022
Pintail ponds	19	6.9	52.6	- 1.7923	Cover-type 2	- 0.4668
Non-pintail ponds	257	93.1	98.1	+ 0.1325	Basin size	- 0.5760
Total	276		94.9		Missouri Coteau	- 0.2826
					Typha	+ 0.4595
					Scirpus	- 0.4306

Table 10. (Continued)

Group	No. of cases	% of total obs.	% of obs. correctly classified	Group centroid[a]	Major discr. variable[b]	Standardized discr. function
Gadwall ponds	13	4.7	38.5	+ 1.8437	Missouri Coteau	+ 0.2248
Non-gadwall ponds	263	95.3	96.6	– 0.0911	Open-water area	+ 0.5260
					Total basins	+ 0.8976
Total	276		93.8		Total wet basins	– 0.6691
					Typha	– 0.3733

[a]Centroid in reduced space of the discriminant scores
[b]Main discriminant variables are listed in the order of their ability to discriminate between groups. The ability of each variable is dependent on the ability of the variables listed prior to it.

Table 11. Within-group means (percent[a]) of major variables discriminating between stock ponds with a species present and stock ponds with the species absent.

Species	Variable	Ponds with species present	Ponds with species absent	All ponds
Blue-winged teal				
	Scirpus[b] (%)	48.2	10.4	17.8
	Missouri Coteau[b] (%)	25.9	8.6	12.0
	Shoreline distance[b] (m)	737	321	403
	Eleocharis[b] (%)	33.3	17.6	20.7
	Cover-type 4 (%)	59.3	69.8	67.8
	Open-water area[b] (ha)	1.1	0.5	0.6
Mallard				
	Shoreline distance[b] (m)	837	323	403
	Pasture[b] (ha)	43.1	55.8	53.8
	Sagittaria[b] (%)	23.3	7.3	9.8
	Fullness 1[c] (%)	4.7	0.4	1.1
Pintail				
	Cover-type 2[b] (%)	63.2	15.2	18.5
	Basin size[b] (ha)	3.9	1.0	1.2
	Missouri Coteau[b] (%)	31.6	10.5	12.0
	Typha (%)	10.5	13.6	13.4
	Scirpus[b] (%)	52.6	15.2	17.8
Gadwall				
	Missouri Coteau[b] (%)	46.2	10.3	12.0
	Open-water area[b] (ha)	1.4	0.6	0.6
	Total basins[b]	5.0	2.8	2.9
	Total wet basins	1.6	2.0	2.0
	Typha (%)	0.0	14.1	13.4

[a] Dummy variables are represented as the percent of the ponds within that group that had this variable present.
[b] The difference in means is significant at the $P<.01$ level.
[c] The difference in means is significant at the $P<.05$ level.

variable, pasture. Pasture was the only variable showing an inverse association with mallard brood ponds. The association of the variables with each group is further supported by differences in within-group means (Table 11). Variables positively associated with mallard ponds (shoreline distance, *Sagittaria* and fullness 1) had larger group means for mallard ponds. Shoreline distance averaged 837 m on mallard ponds compared to 323 m on non-mallard ponds. Differences between within group means were significant (P<.01) for shoreline distance, pasture and *Sagittaria*.

Pintail

Pintail ponds were best discriminated by cover-type 2, basin size, the Missouri Coteau, *Typha* spp. and *Scirpus* (Table 10). These five variables correctly classified 87.7 percent of the ponds. Over 52 percent of the ponds with pintail broods were correctly classified. The large distance between the group centroids indicated that the difference between pintail ponds and non-pintail ponds was more pronounced than in the previous two analyses. Cover-type 2 was the best single discriminating variable with a direct association occurring with pintail brood ponds. Considering all five variables together, basin size was slightly more influential. *Typha* was the only variable that showed an inverse relationship with pintail broods. Differences in means (Table 11) was significant for all variables except *Typha*. The values of the group mean further support the association as inferred by the group centroid and the discriminant function. Cover-type 2 occurred on 63.2 percent of the pintail ponds and on 15.2 percent of the non-pintail ponds. Mean pond size with pintail brood use was 3.9 ha compared to 1.0 ha for non-brood ponds.

Gadwall

Five variables correctly classified 38.5 percent of the gadwall brood ponds while only 4.7 percent of the ponds had gadwall broods. Thus, considerable improvement over chance classification was achieved. The total of all ponds correctly classified was 93.8 percent. The Missouri Coteau was the single most important discriminating variable. However, considering all five variables together, total basins was almost four times more influential than the Missouri Coteau in discriminating between groups. The Missouri Coteau, open-water area and total basins have a positive relation with gadwall brood ponds. Total wet basins and *Typha* had an inverse relationship with the former variable having the second largest discriminant function value. The difference in means within groups (Table 11) was significant ($P<.05$) for the Missouri Coteau, open-water area and total basins. Almost half of all gadwall brood ponds were located in the Missouri Coteau. Mean total basins on a plot was 5.0 for gadwall ponds and 2.8 for non-gadwall brood ponds. *Typha* was not a dominant emergent vegetation on any of the ponds that contained gadwall broods. The values of these means agree with the relationships indicated by the group centroids and discriminant function signs.

Between all four species

Discriminant analysis of all four species resulted in two discriminant functions and nine important variables (Table 12). The percentage of

Table 12. Major independent variables discriminating between stock ponds utilized by duck broods as indicated by stepwise forward discriminant analysis.

Group	No. of cases	% of total obs.	% of obs. correctly classified	Group centroid[a] 1st	Group centroid[a] 2nd	Major discr. variable[b]	Standardized discr. function	
Blue-winged teal	54	41.9	66.7	- 0.0844	+ 0.3534	Total basins	+ 0.6763	+ 0.0965
Mallard	43	33.3	58.1	- 0.5134	- 0.3068	Cover-type 2	+ 0.6788	- 0.2924
						Pasture	+ 0.4353	+ 0.3253
Pintail	19	14.7	36.8	+ 0.8020	- 0.0051	Pierre Hills	- 0.1227	- 0.6750
Gadwall	13	10.1	38.5	+ 0.8768	- 0.4459	Percent open water	+ 0.2193	- 0.7196
Total	129		56.6			*Sagittaria*	- 0.1756	- 0.6048
						Total stream water	+ 0.0790	- 0.7905
						Total wet basins	- 0.1776	+ 0.3067
						Hayland	+ 0.2551	+ 0.2361

[a]Centroid in reduced space of the discriminant scores
[b]Main discriminant independent variables are listed in the order of their ability to discriminate between groups. The ability of each variable is dependent on the ability of the variables listed prior to it.

each group correctly classified were teal, 66.7; mallard, 58.1; pintail, 36.8 and gadwall, 38.5. Total percentage correctly classified was 56.6. The value and sign of the discriminant function indicated the relative importance and relation of each variable to a group in the corresponding centroid. The first discriminant function distinquished blue-winged teal and mallards from pintails and gadwalls, while the second function differentiated teal from the other three. The relative effects of the nine variables on the four species were plotted in two dimensions (Figure 2). Values of the first discriminant function were plotted on the horizontal axis, while the values of the second function were plotted on the vertical axis. Much of the discriminating power of the first function was attributed to total basins per plot, cover-type 2 and pasture. The ability of the second function to discriminate was due mainly to the Pierre Hills, percent open water, Sagittaria and total stream water. The positive discriminant function values of total basins, pasture and hayland indicated an inverse association with mallard broods (both centroids are negative). Likewise, there existed a positive relationship of mallards to the Pierre Hills and the occurrence of Sagittaria as a dominant emergent vegetation. Blue-winged teal broods had an inverse relationship with cover-type 2, percent open water and total stream water per plot. Wet basins per plot were directly associated with teal broods. Both pintails and gadwalls showed a close association with total number of basins per plot and cover-type 2. Gadwalls exhibited an inverse association with the number of wet basins present on the plot. The centroid location for each species (Figure 2) showed pintail and gadwall

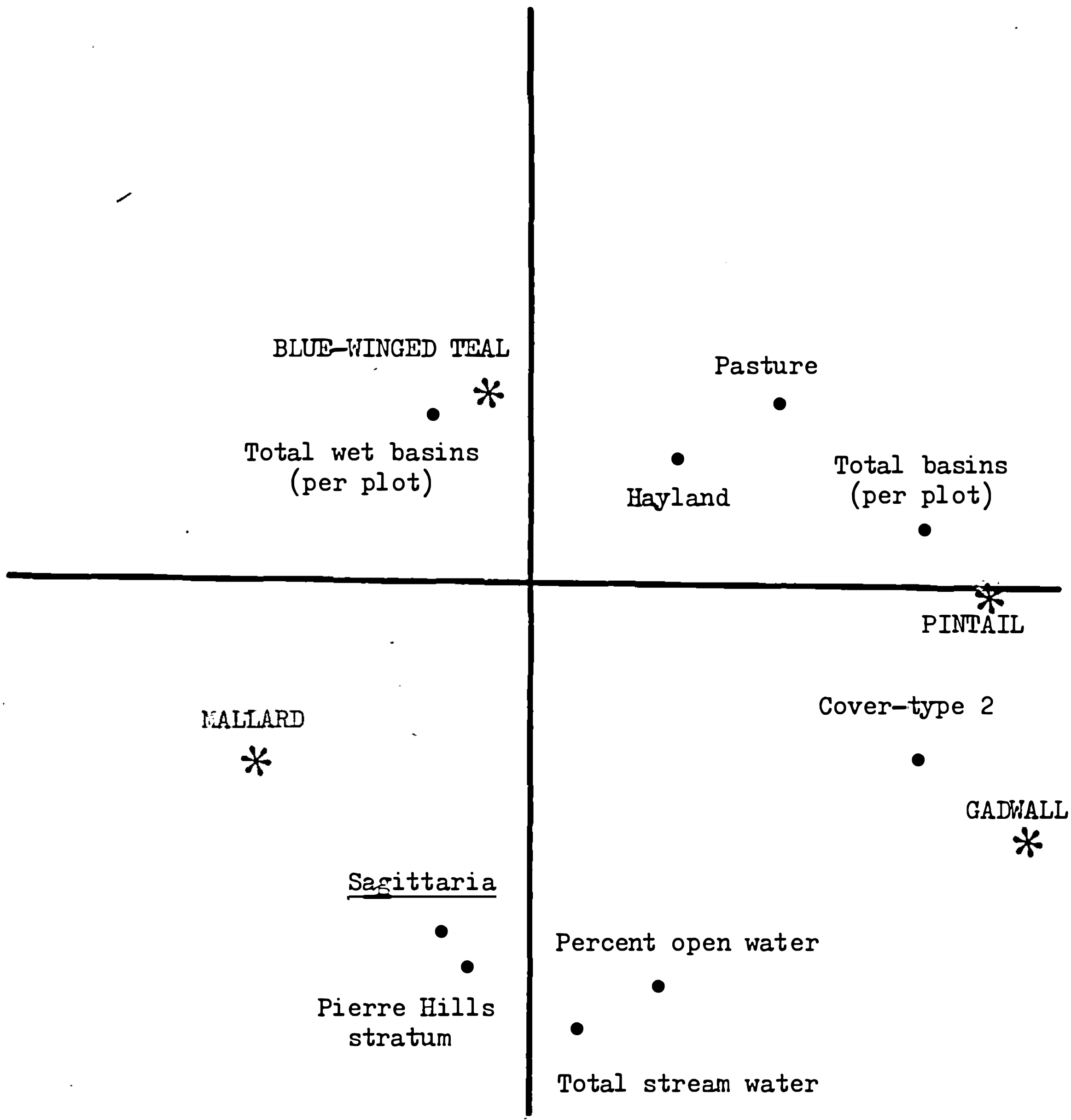

Figure 2. Plotted position of group centroids and standardized discriminant functions from discriminant analysis of all four species. The relationship of each variable with a species of brood is inferred by their position within the four quadrants and the distance between points. Nearness of a variable to a species demonstrates a positive association existing between the two as indicated within the discriminant equation.

broods to be quite similar in their preference of ponds.

The overall association of variables with species of broods can also be seen in the differences of group means (Table 13). The mean total number of basins on a plot was the highest for pintails and gadwalls, 4.11 and 5.00 respectively. Gadwalls used ponds with the lowest (1.62) mean number of wet basins on a plot. Open-water area was the smallest for teal and the largest for pintails and mallards (area ranged from 1.11 ha for teal to 1.51 ha for pintails). The Pierre Hills had a high usage by mallard and pintail broods; 58.1 percent of the mallard ponds and 42.1 percent of the pintail ponds occurred in this region. Pintails showed a preference for cover-type 2. Stock ponds of this cover-type represented 63.2 percent of all pintail brood ponds. Over 50 percent of the stock ponds used by each of the other three species had a cover-type 4. Mallard broods used ponds located on plots with a small amount of pasture but a large area of hayland. Differences in means were significant (P<.01) for total basin number, cover-type 2 and the Pierre Hills stratum.

Age of broods

Almost 50 percent of age groups of broods were correctly classified by six variables; cloud cover, percent open water, the Missouri Coteau, fullness 3, hayland and percent surface water (Table 14). The percentage of each group correctly classified was class I, 68.4; class IIa, IIb, 24.4; and class IIc, III, 50.0. The first discriminant function was able to separate the three groups with class IIa, IIb being located in the center. The second function was responsible for separating the middle age-group from the other two (Figure 3).

Table 13. Within-group means (percent) of major variables that discriminate between stock ponds utilized by different species of broods.

Variable	B.w. teal	Mallard	Pintail	Gadwall	Total
Wetland-upland variables					
Open-water area (ha)	1.11	1.49	1.51	1.36	1.32
Total basins[a]	3.33	2.44	4.11	5.00	3.32
Total wet basins	1.81	1.79	1.84	1.62	1.79
Total stream water (ha)	0.03	0.05	0.07	0.08	0.05
Hayland (ha)	2.40	3.50	1.65	0.73	2.49
Pasture (ha)	49.28	43.10	53.95	54.94	48.48
Dummy variables[b]					
Sagittaria (%)	24.1	23.3	5.3	15.4	14.7
Pierre Hills[a] (%)	29.6	58.1	42.1	15.4	39.5
Cover-type 2[a] (%)	22.2	25.6	63.2	38.5	31.0

[a]Difference in means is significant ($P<.01$).
[b]Variables were recorded as being present or absent. Values represent the percent of ponds, with the species present, having that variable present.

Table 14. Major independent variables discriminating between stock ponds utilized by different age-groups of broods as indicated by stepwise forward discriminant analysis.

Group	No. of cases	% of total obs.	% of obs. correctly classified	Group centroid[a] 1st	Group centroid[a] 2nd	Major discr. variable[b]	Standardized discr. function	
Class I	57	41.9	68.4	− 0.4512	+ 0.1924	Cloud cover	− 0.5273	− 0.5910
Class IIa, IIb	45	33.1	24.4	+ 0.0366	− 0.4208	Percent open water	− 0.4107	+ 0.1264
						Missouri Coteau	+ 0.5360	− 0.3891
Class IIc, III	34	25.0	50.0	+ 0.7079	+ 0.2344	Fullness 3	− 0.3518	+ 0.6742
Total	136		49.3			Hayland	+ 0.6311	+ 0.0118
						Percent surface water	+ 0.4296	+ 0.5439

[a] Centroid in reduced space of the discriminant scores

[b] Main discriminant independent variables are listed in the order of their ability to discriminate between groups. The ability of each variable is dependent on the ability of the variables listed prior to it.

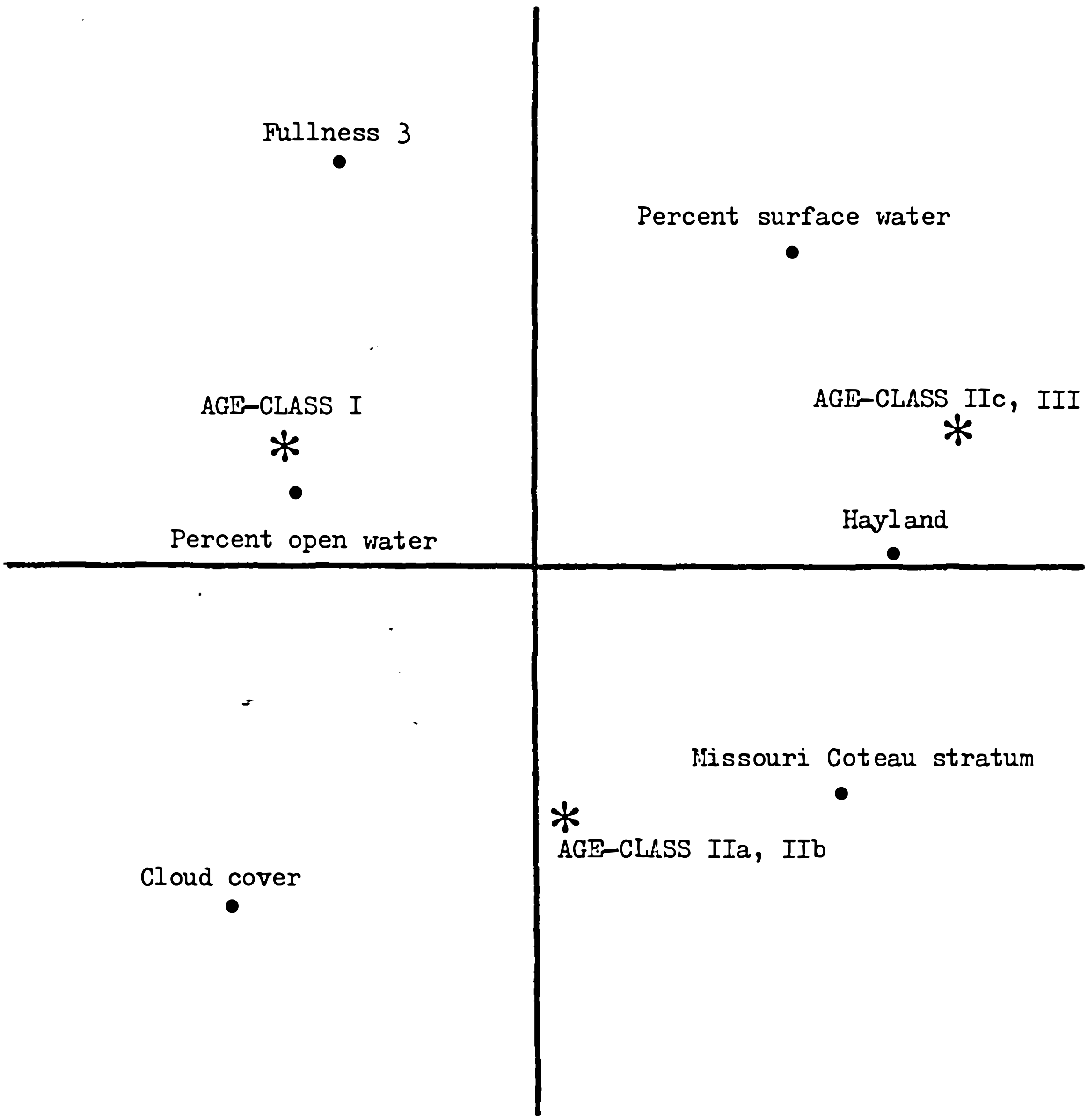

Figure 3. Plotted position of group centroids and standardized discriminant functions from discriminant analysis of different age-groups of broods. The relationship of each variable with an age-group is inferred by their position within the four quadrants and the distance between points. Nearness of a variable to an age-group demonstrates a positive association existing between the two as indicated within the discriminant equation.

Cloud cover was closely associated with younger broods. The mean overcast was more than 20 percent for younger broods compared to 5.3 percent for class IIc, III broods (Table 15). Percent open water was positively related to class I broods. The mean percentage of open water for ponds with class I broods was 88.3 compared to 75.3 for class IIc, III broods; this was significant (P<.05). Younger broods also occurred on shallower ponds. About 42 percent of the ponds containing class I broods had a fullness 3 rating. A majority of older class broods were present on ponds with near normal water level (fullness 2). Percent surface water and hayland were both directly associated with older aged broods (age-class IIc, III). However, the difference in means between groups was not significant (P<.05).

Table 15. Within-group means (percent[a]) of major variables discriminating between stock ponds utilized by different age-groups of broods.

Variable	Age-class I	Age-class IIa, IIb	Age-class IIc, III	Total
Cloud cover[b] (%)	20.5	23.0	5.3	17.5
Percent open water[b]	88.3	83.9	75.3	83.6
Missouri Coteau (%)	14.0	31.1	26.5	22.8
Fullness 3[b] (%)	42.1	20.0	23.5	30.2
Hayland (ha)	0.9	2.1	3.0	1.8
Percent surface water	69.5	66.2	80.3	71.1

[a] Dummy variables are represented as the percent of the ponds with that age brood having that variable present.
[b] Difference in means is significant ($P<.05$).

DISCUSSION

Temperature and cloud cover were the only non-habitat variables that were important in the analyses. The negative association of temperature with mallard and blue-winged teal broods in regression and the positive association of cloud cover to younger ducklings indicated that weather conditions affected the observability of broods. Blankenship et al. (1953) noted that the time of day may be important during brood censusing. During our censusing, broods were flushed from upland vegetation on several occasions. The importance of temperature and cloud cover, plus the "beat out" in emergent vegetation suggested that younger broods resorted to upland cover for shade when pond and shoreline vegetation was sparse or lacking.

The relationship between brood use of a pond and upland land use was probably due more to nesting than to actual brood use. However, Evans et al. (1952) and Berg (1956) reported that older broods migrated overland to more preferred ponds. Several upland land use variables were important in both regression and discriminant analyses. Alfalfa, hayland, pasture, fallow and strata were found to be important in the analyses. Alfalfa was positively related to teal brood density on a pond. Studies in North Dakota (Salyer 1962), Minnesota (Ordal 1964), Iowa (Burgess et al. 1965) and Nebraska (Evans and Wolfe 1967) have reported alfalfa as being a common nesting cover of teal. Evans and Wolfe (1967) reported 21.6 percent of the teal nests located in alfalfa to be successful; Ordal (1964) reported 31 percent success. Both pasture and hayland exhibited negative relationships with mallard brood density and presence on a stock pond. Gates (1965) reported a relatively lower nesting density for mallards in hayland (alfalfa and grasses) when compared to teal. The lower density for mallards was not due to difference in vegetational preference but to the availability of cover during nest initiation (Keith 1961 and Gates 1965). Gates further suggested that a larger portion of the mallard nests were renests that occurred when the vegetation was taller and denser. Jessen et al. (1964) reported that mallards utilized a wide range of vegetation types for nesting but generally preferred dense vegetation over 9.4 cm in height. Grazing of pastures and mowing of hayland in late-June through July within the study area removed residual cover that would have been available the following spring. The importance of residual cover for nesting mallards was supported by the negative association with hayland and pasture and the positive relationship with fallow. Fallow fields included cropland not yet cultivated by mid-May; this included fields revegetated with annual weeds. Mallards may have taken advantage of these idle, revegetated areas for early nesting.

Variables associated with pond size and water conditions were the common variables that entered into analyses. Shoreline distance was the single most important variable in explaining both the presence and the number of broods on a pond. The high correlation and interrelationship of shoreline distance with basin size, surface-water area, open-water area, total stock pond basin and total stock pond water reduced the importance of the latter variables in explaining brood density on ponds. Of all the highly correlated variables associated with water conditions shoreline distance best explained the variance in the number of broods per unit area. The negative relationship of shoreline distance and the number of broods indicated that larger ponds produced more broods but less broods per unit area. The shoreline distance of stock ponds with the highest density (0.41 to 1.00 ha) was approximately 443 m. Trauger (1967) working with natural wetlands reported ponds with a shoreline distance between 457 and 914 m to have the highest brood density. Trauger reported natural wetland size between 2.0 and 4.0 ha as having the highest brood densities. Multiple regression analysis on natural ponds (Paterson 1976) showed shoreline distance to be significant ($P<.05$) in determining brood numbers on a pond. Paterson found pond size significant ($P<.05$) for breeding pair numbers but it was nonsignificant for brood numbers.

Percent surface water was negatively associated with the density of mallards, teal, and total broods on ponds. This association is likely due to the brood movement from less permanent wetlands to stock ponds during drought years. Also a slight increase in surface-water area decreased brood density. Throughout the four years an average of one-third of all basins located on plots with stock ponds were completely dry by July with a large number of the wet ponds being less than one-fourth their normal water level. Older aged ducklings were associated with ponds with a large percent surface water. This agrees with the observation that brood movement was from stock ponds of greater water loss to ones of less water loss (Berg 1956).

The presence of other ponds on a plot played an important role in brood use of a stock pond. Discriminant analysis of all four species showed that teal broods have the highest use of stock ponds located in areas of high wet basin density. The use of stock ponds decreased with the occurrence of intermittent streams. Regression analysis of teal broods showed a similar relationship by the negative association of teal density with total stream basin. However, within the regression analysis total stream water was positively associated. This was due to the interaction of variables since the simple correlation of both stream variables was negative. Intermittent streams were generally a series of pools with depths of up to 60 cm. Blue-winged teal broods may prefer the intermittent streams because of the closeness of pools and the variation in vegetation type due to water depth. The presence of mallard broods and their densities on stock ponds was not greatly affected by the number of ponds on a plot. Of the four species, mallard broods had the highest use of stock ponds located on plots with low basin densities. Gadwalls, however, were positively associated with stock ponds located in areas of high basin density. A large portion of these stock ponds occurred in the glaciated Missouri Coteau. In the spring, temporary glacial wetlands are used as breeding ponds by gadwall. As the summer progresses, these shallower ponds begin to dry. This forces broods to move to the deeper, more stable stock ponds. Movement to stock ponds during dry conditions was indicated by the negative association of gadwall broods with total number of wet basins on the study plot. Evans and Black (1956) and Gates (1962) reported that gadwall broods preferred larger, more open marshes and impoundments.

Percent open water was important in determining total brood densities and pond preferences by a species. All broods, except gadwalls, were negatively associated with percent open water. The distribution pattern of emergent vegetation was also important to broods. Cover-type 3 and cover-type 1 were both negatively associated with total brood density; indicating brood preference for ponds with some emergent vegetation in a dispersed pattern (cover-type 2). The negative association of cover-type 3 and cover-type 1 with brood density cannot be attributed to the large amount of emergent vegetation reducing brood visibility since brood density increased with a decrease in percent open water. Cover-type 2 was most important in determining if a pond was suitable for pintail broods. Trauger (1967) and Stoudt (1971) reported higher brood density on natural wetlands with more than 60 percent open water. Lokemoen (1973) reported percent of the pond with emergent vegetation to be significant ($P<.05$) for pintail (positive association) but nonsignificant for mallard and blue-winged teal broods. Older aged broods (age-class IIc, III) were associated with more vegetated ponds. Berg (1956) reported brood movement from stock ponds with emergent vegetation sparse or lacking to ponds with more emergent vegetation.

Broods of each species showed a preference for a particular species of emergent vegetation. _Sagittaria_ and _Scirpus_ were important in determining if a pond was suitable for broods. These two genera were representative of the taller, denser vegetation (_Scirpus_) and the shorter, leafier vegetation (_Sagittaria_). _Alisma_ and _Sagittaria_ were associated with increased total brood density on a pond. Vegetation type was not a major variable discriminating between age classes of broods. This suggests that older, more mobile broods did not actively seek ponds with these vegetation types. Berg (1956) reported brood movement from bare open stock ponds to ponds with Eleocharis spp., Sagittaria and Alisma associations as the dominant emergent vegetation. Scirpus and Eleocharis were the more preferred vegetative types for teal. Bennett (1938) reported Scirpus associations to be the most important vegetation used by blue-winged teal broods. Eleocharis was often the only emergent vegetation present on ponds with a cover-type 4 and occurred in the extremely shallow water and along the moist shoreline. Mallard broods had a positive association with Sagittaria. Pintails showed a negative association with Typha but a positive association with Scirpus. Unlike broods of other species, gadwalls showed no preference for any type of vegetation but were negatively associated with the presence of Typha on the stock pond. The low association of gadwall broods with emergents was to be expected since the broods prefer larger, more open marshes and impoundments (Evans and Black 1956 and Gates 1962).

MANAGEMENT SUGGESTIONS

Suggestions concerning management of stock ponds for better waterfowl production include the following:

1. Smaller stock ponds (surface-water area between 0.40 and 1.00 ha) dispersed over the area would be more beneficial than one large pond of equal surface-water area. The effect of this would be increased shoreline distance, dispersed grazing pressure and increased waterfowl production.

2. A portion of the pond (primarily the upstream end) and immediate surrounding upland should be fenced from livestock. This would allow the establishment of aquatic vegetation, reduce siltation and provide shade and protection for broods. The potential effect of fencing on predator concentration and predation on nesting hens or on broods is unknown.

3. Fenced ponds should be opened to grazing when emergent vegetation becomes too dense for brood use.

4. Control of overgrazing through sound grazing practice, including deferred grazing, would be highly beneficial to duck production.

5. Construction of stock ponds in areas with high densities of temporary natural wetlands will provide a stable brood rearing pond, especially during drought years when the shallower natural basins dry up.

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